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Procedures For Making Precision CH Bumps On Capsules

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Subject: Procedures for making precision CH bumps on capsules

Introduction

Recently we were asked to produce target capsules with bumps on the surface. The bumps were to test the effects of fill tubes in future targets. The bumps desired were to be Gaussian in shape and from 60 to 40 μm in diameter and from 1 to 6 μm high. The capsules had a nominal diameter of 500 μm. The approach we used was to align a precision aperture to the capsule and coat through the aperture onto the capsule surface using plasma polymer coating.[1] The bumps were characterized using optical microscopy, Wyko interferometry, and AFM sphere mapping.

Bump production

We used two commercial suppliers of apertures (National Aperture, Edmund Optical). In addition we investigated the possibility of producing custom apertures using facilities available at LLNL. Holes were EDM drilled in brass foil using Damon Jackson's facility. The holes were very circular and this looked like a promising approach. Damon had only one custom fabricated 50 μm drill that was in the range we needed. We chose the commercial apertures because of the wider range of diameters available that met our needs. Laser drilled holes were fabricated from 30 to 70 μm diameter. The laser drilled holes showed considerable irregularity at the edge.

We found that it was important to inspect each aperture prior to coating because of the possibility of dirt particles in the aperture. Apertures were cleaned in ethanol using ultrasonic agitation dried and inspected. The clean apertures were installed in a mounting ring using Duco Cement that allowed easy removal and reuse of the mounting ring. The mounting ring allowed the surface of the aperture to be recessed below the outer edge by about 400 μm. This spacing allowed the tenting film to have a reasonable tightness over the shell. The mounted aperture was placed into a fixture with a hole that accepted the aperture mount and also had tapped holes that received the bolts on the top holder. The shell was loaded onto the aperture surface. An attempt was made to locate the shell as close to the aperture hole as possible. A 2 μm polycarbonate film (Spectro-Film PolycarbTwo, Somar Int'l.) mounted in an x-ray fluorescence film (XRF) holder ring was anti-static treated with a polonium source and then carefully lowered over the capsule.

The capsule and aperture were viewed by microscope from above while illuminating the aperture from below with a fiber optic illuminator. The ring-mounted film was then carefully

[1] Bob Cook, "Single Bump on a Shell Fabrication," LLNL Technical memo, February 13, 2004. Copy available from Bob Cook.

translated to align the capsule to the aperture. All alignment was performed using only optical observation. This appeared sufficient to achieve an alignment accuracy of about 20 µm. The top holder was positioned carefully and the two bolts threaded loosely into the bottom mount. The alignment was retested and adjusted as needed and the clamping bolts were tightened. Since a stereo microscope was used for alignment one had to compensate for parallax offset. The alignment was observed separately from each eyepiece to split the difference between the two views. The assembled structure was inverted and reexamined to assure accurate centering of the hole and the center of the capsule. It would be desirable to have a higher power measuring microscope to avoid parallax problems although the equipment used was sufficient to achieve excellent uniformity and reproducibility of the bump structures.

Figure 1 is a cartoon drawing of the holding and alignment fixture for the shell and aperture showing the top and bottom holders, the XRF film holder ring with the polycarbonate film installed, and the shell and aperture in the mounting ring. Figure 2 is a photograph of the physical holding fixture and Figure 3 is a photograph of the microscope setup for this work.

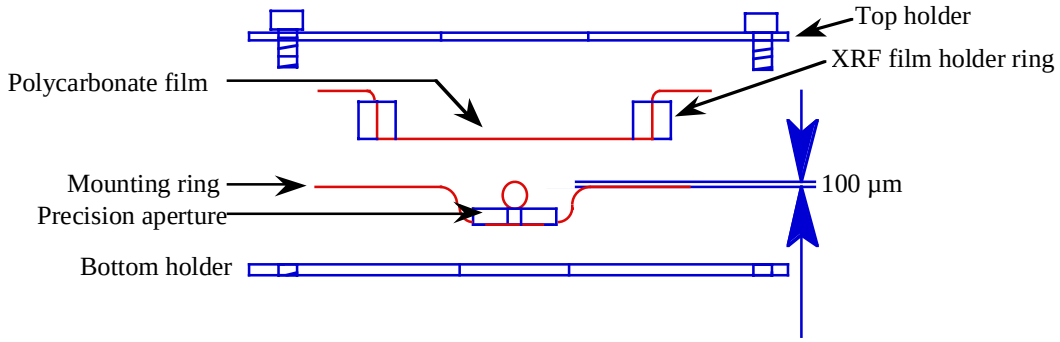

Figure 1. Drawing of fixture to align and hold capsule and aperture in place for coating a bump on a capsule.

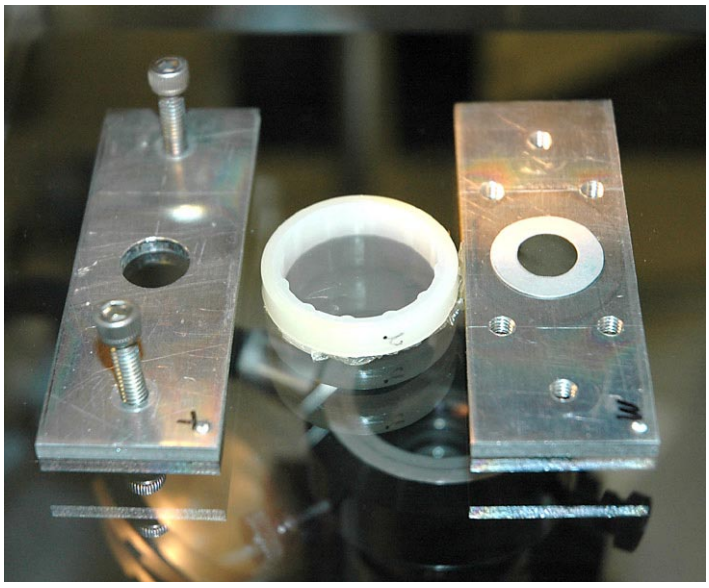

Figure 2. Photograph of physical fixture diagrammed in figure 1.

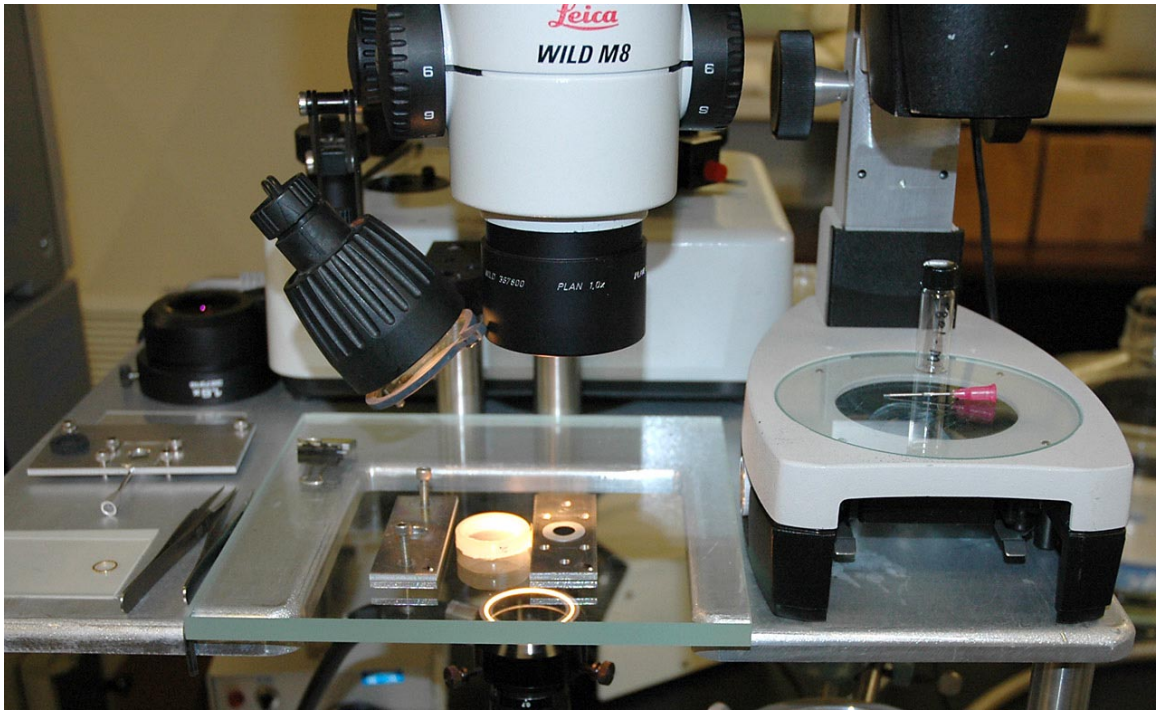

Figure 3. Photograph of microscope setup used to align shell and aperture in holding fixture.

The fixture holding the capsule and aperture was placed in the plasma polymer coater. The capsule holder was placed on the mounting table with a stack of four glass slides (0.160 inch thick) that provides a stable surface and provided clearance for the screw heads. The substrate holder was adjusted in height to 1.269 inch below the chamber edge. The capsule was aligned to within 1 mm of the center of the chamber using an acrylic alignment fixture. Witness surfaces were placed alongside the opening in the top holder plate to assist in getting deposition rate information. The gas flows were 0.3 sccm for trans-2-butene and 10 for hydrogen. The chamber pressure was controlled to 98 mTorr and the discharge power was 10 watts. The rate of coating at this position deposited a 3 µm bump in 6.33 hours. A list of coating time, witness surface coating rate, aperture diameters, bump height, and bump width at half-height is shown below.

		Witness surf thick (µm)						WYKO	Sphere Mapper	
Run	Coating time (hrs)	left	right	ave.	coat rate (µm/hr)	Aper OD (µm)	Shell dopant	bump ht (µm)	bump ht (µm)	width at half-ht (µm)
PTS467	9.8	7.43	9.24	8.3	0.9	40	Ge	4.7	5.4	45.8
468	9.8	8.17	10.36	9.3	0.9	50	Ge	4.6	5.5	51.4
472	6.33	5.52	5.83	5.7	0.9	50	Ge	3.05	3.7	49.6
473	2.12	1.82	2.09	2.0	0.9	50	Ti	0.88	1.1	51.9
474	2.12	1.45	2.08	1.8	0.8	40	Ti	1.08	1.6	35.4
475	4.24	3.57	4.58	4.1	1.0	40	Ti	2.44	3.0	38.3
476	4.24	3.61	3.95	3.8	0.9	50	Ti	1.8	2.3	54.4
477	6.33	5.65	6.12	5.9	0.9	50	Ge	2.65	3.2	48.9

Bump characterization

After coating the bump through the aperture the capsule was next mounted for characterization. To pick up the capsule a small piece of gel film (WF-80-X0, Gel=Pak, Inc.) about 3 mm square was adhered to a 1 x 3 inch glass slide. The slide was handled with thin forceps and carefully aligned over the capsule. The gel film spot was then slowly lowered, viewing through a microscope, until the capsule was just touching the gel film. The slide was carefully lifted off the aperture and inverted so that the capsule was facing upward. The capsule was next examined using a microscope to locate the bump feature. A vacuum chuck with a plastic tube was used to gently push and roll the capsule until the bump was precisely oriented upward at the "pole" position. An optical micrograph of a mounted capsule with a 55 x 3 μm bump is shown in Figure 4.

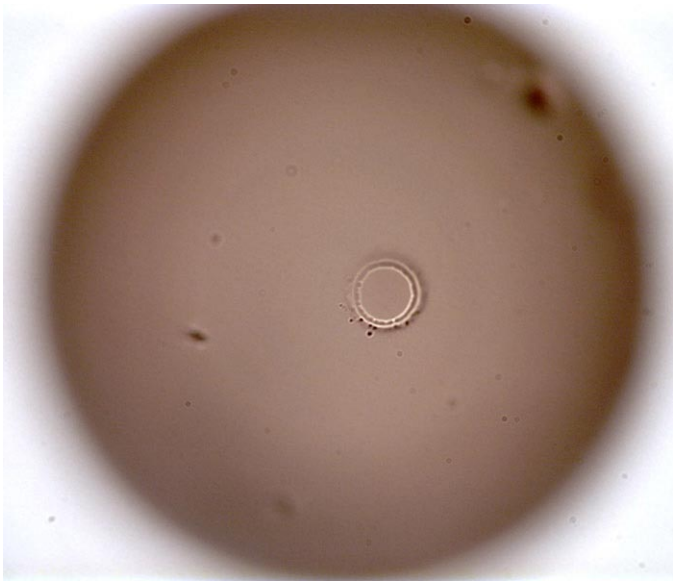

Figure 4. Optical photomicrograph of capsule with CH bump on the pole.

The mounted shell was next examined on the WYKO interferometer. The capsule was first located at low magnification. The magnification was next increased to 50X and the stage tilted until the bump was precisely at the pole position and the interference fringes on the bump and on the shell are circular and concentric. A scan was taken and saved. The scan was next masked to exclude the bump from the curvature correction. The scan was then corrected for curvature and tilt and the flattened image analyzed for feature dimensions. A WYKO image and profile measurement is shown in Figure 5. Because of the steepness of the edge of the bump the WYKO interferometer is unable to detect the fringe movement through this portion of the bump. The area that is not detected is shown as a black area in the color image.

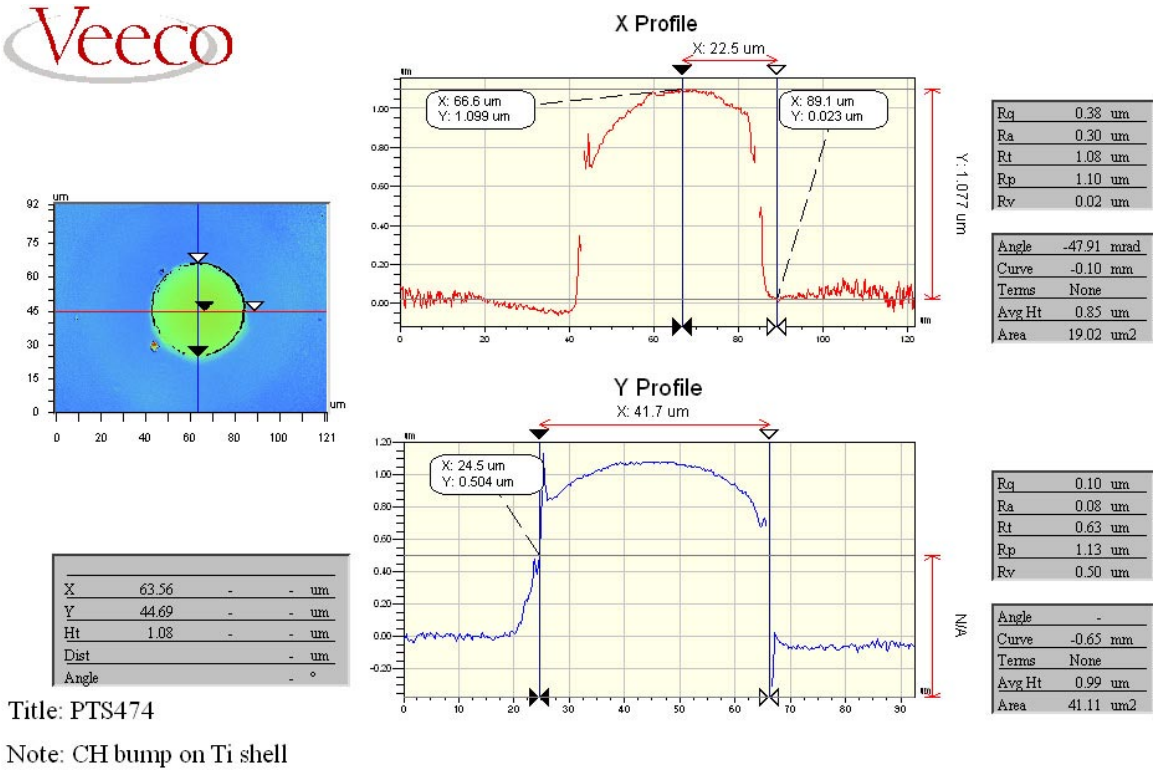

Figure 5. Results from WYKO interference microscope for one of the bumps added to a capsule. Note the black area in the picture on the left, indicating no data.

The shell was next transferred to the sphere mapping AFM and held on a vertical vacuum chuck. The capsule was adjusted until the bump was positioned at the “equator” position, which frequently required several attempts to achieve a satisfactory alignment. The capsule was then rotated and traces were collected at spacing ranging from 5 to 10 µm intervals. AFM mapping is limited to bumps up to 5 µm high because of the 6 µm dynamic range limitation of the AFM probe. Figure 6 shows 10 AFM traces through a 60 x 3 µm bump. The bump shape qualitatively agrees with the profile found by interferometry but has the advantage of not being discontinuous because of the undetected steep edge region. The height measured on the WYKO and the AFM sphere mapper were consistently different with the WYKO measuring about 20% shorter heights. The discrepancy was caused by the calculated flattening correction on the WYKO. Bump width at half-height was calculated using the capsule diameter to convert degrees width to µm width.

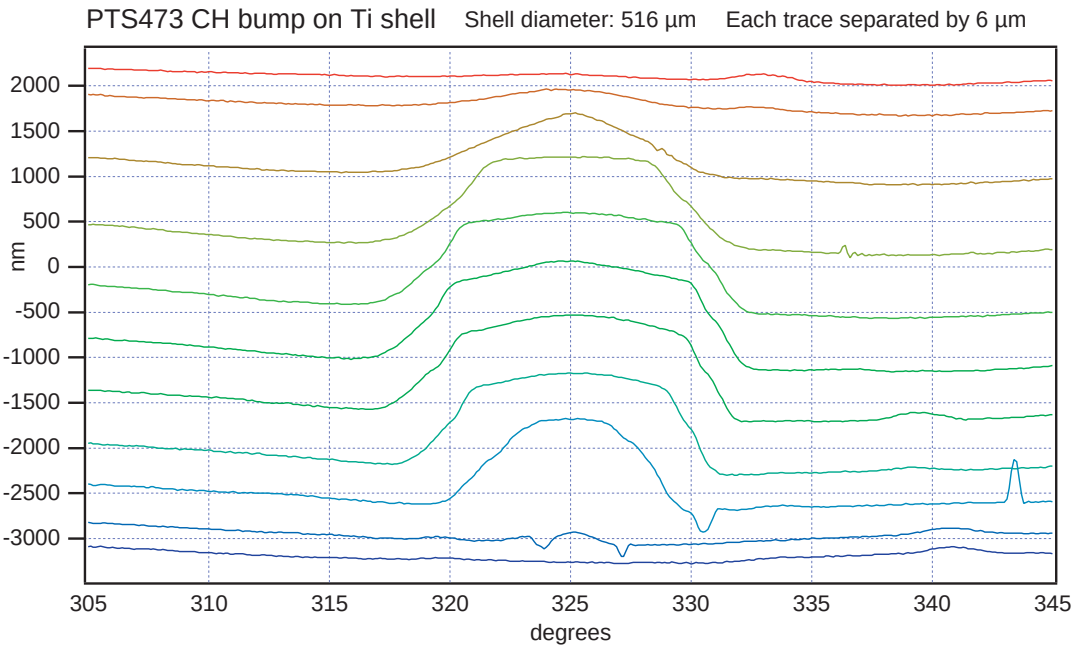

Figure 6. AFM Sphere Mapper band map traces of a CH bump on a shell.

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